L SURVEYS OF CANADA GEESE AND BLACK DUCKS IN EASTERN CANADA

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AERIAL SURVEYS OF CANADA GEESE AND BLACK DUCKS IN EASTERN CANADA

by

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Migratory Bird Populations Station
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ABSTRACT

This report summarizes results from aerial surveys of Canada geese and black ducks in eastern Canada. Information presented is based on data obtained during the summer of 1956, 1962-66 for Canada geese and during the spring of 1955, 1956, 1963-66 for black ducks.

Canada geese show extreme variations in density in eastern Canada. Density strata have been delineated. Sampling error in the stratified sample of Canada geese exceeded $\pm$ 20 percent at the 95 percent confidence level, but estimates of optimum sample allocations indicate that it may be reduced to less than that. The estimated number of geese in Canada east of James and Hudson Bays approximates the number accounted for by the Atlantic Flyway winter survey and kill estimates. The extent to which the two populations are the same is unknown.

The visibility from aircraft of breeding black ducks is extremely low. Distribution of black ducks within the survey area is quite uniform and some apparent differences may be due to variable conditions during observation. With the Bureau's present resources, a statistically reliable design for sampling black ducks breeding in eastern Canada is not feasible. Based on areas with consistent coverage and weighted toward annual comparability in group sizes, the black duck breeding population index appears to have been decreasing each year since 1963. Without adjustment for visibility, the index figure equals approximately one-eighth of the Atlantic Flyway winter survey figure.

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Frontispiece. Two views most typical of the area surveyed for Canada geese. Above, continental tundra. Below, open boreal forest and muskeg.

INTRODUCTION

This report presents results of aerial surveys of Canada geese and black ducks nesting in eastern Canada. The aerial surveys were initiated to obtain annual indexes to the size of the fall flight with the objective of providing bases for determining suitable hunting season lengths and bag limits. The history of aerial surveys in eastern Canada has been described in an earlier report (Chamberlain and Kaczynski, 1965) and will not be detailed here.

METHODS

General

Aerial survey transects for waterfowl are one-fourth mile wide strips visually estimated (one-eighth mile on each side of the aircraft) as they are flown cross-country. Division of the transect into 18-mile-long segments is useful for statistical treatment, waterfowl distribution delineation, and navigation. When topographic conditions permit, the transects are flown at 200 to 300 feet above the ground. In eastern Canada, rough terrain often makes it necessary to fly higher than the preferred altitude. The aircraft used in eastern Canada since 1962 is a twin-engine amphibian (Grumman Goose). Speed on the transects is about 120 miles per hour. Waterfowl observations are dictated into a recorder.

Because both the duck and goose surveys were experimental and exploratory, the pattern of aerial transects in eastern Canada was variable. Canada goose survey transects were standardized in 1965 (fig. 1) and, except for a planned westward extension into the Churchill, Manitoba, area in 1967, little change is foreseen. Black duck survey transects were standardized in 1967 (fig. 2). They have been rather evenly distributed through the survey area.

The eastern Canada survey has been conducted in two phases. The first phase, from early May to mid-June, was a survey primarily of black duck breeding pairs. This survey was limited in its northward extension to about 54° north latitude because lakes further north were still ice-covered in mid-June. Hence it was not possible to cover the northernmost range of the black duck breeding population. The second phase, from early July to mid-August, covered the same area as the first to obtain a count of duck broods, and in addition continued northward to survey Canada geese on transects up to the Hudson Strait. Beginning in 1967 that part of the survey designed to record duck broods was discontinued, allowing all of the effort in July and August to be directed toward the survey of Canada geese. Data from the black duck brood survey were too limited to merit continuance.

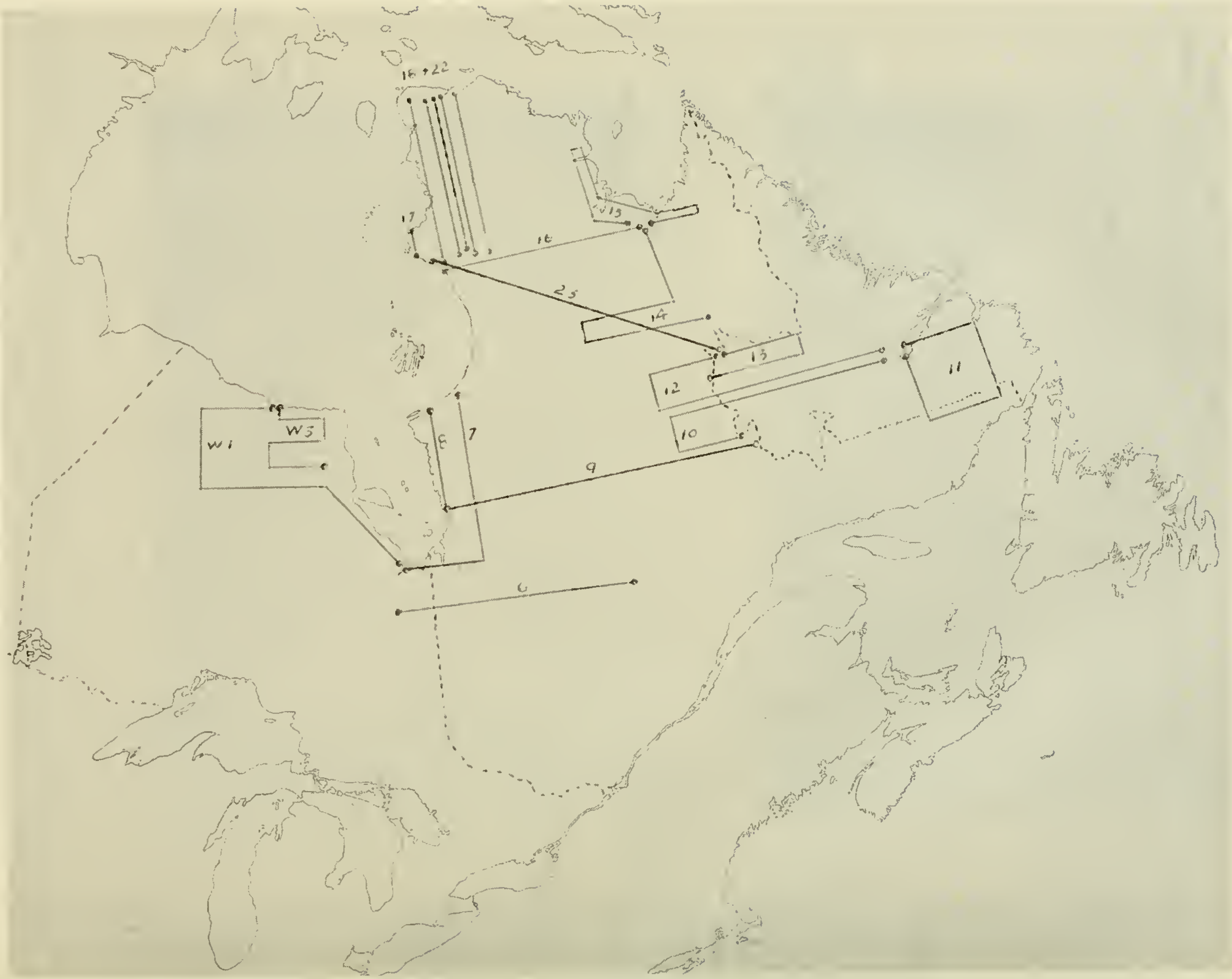

Figure 1.--Canada goose survey transects, 1965-66.

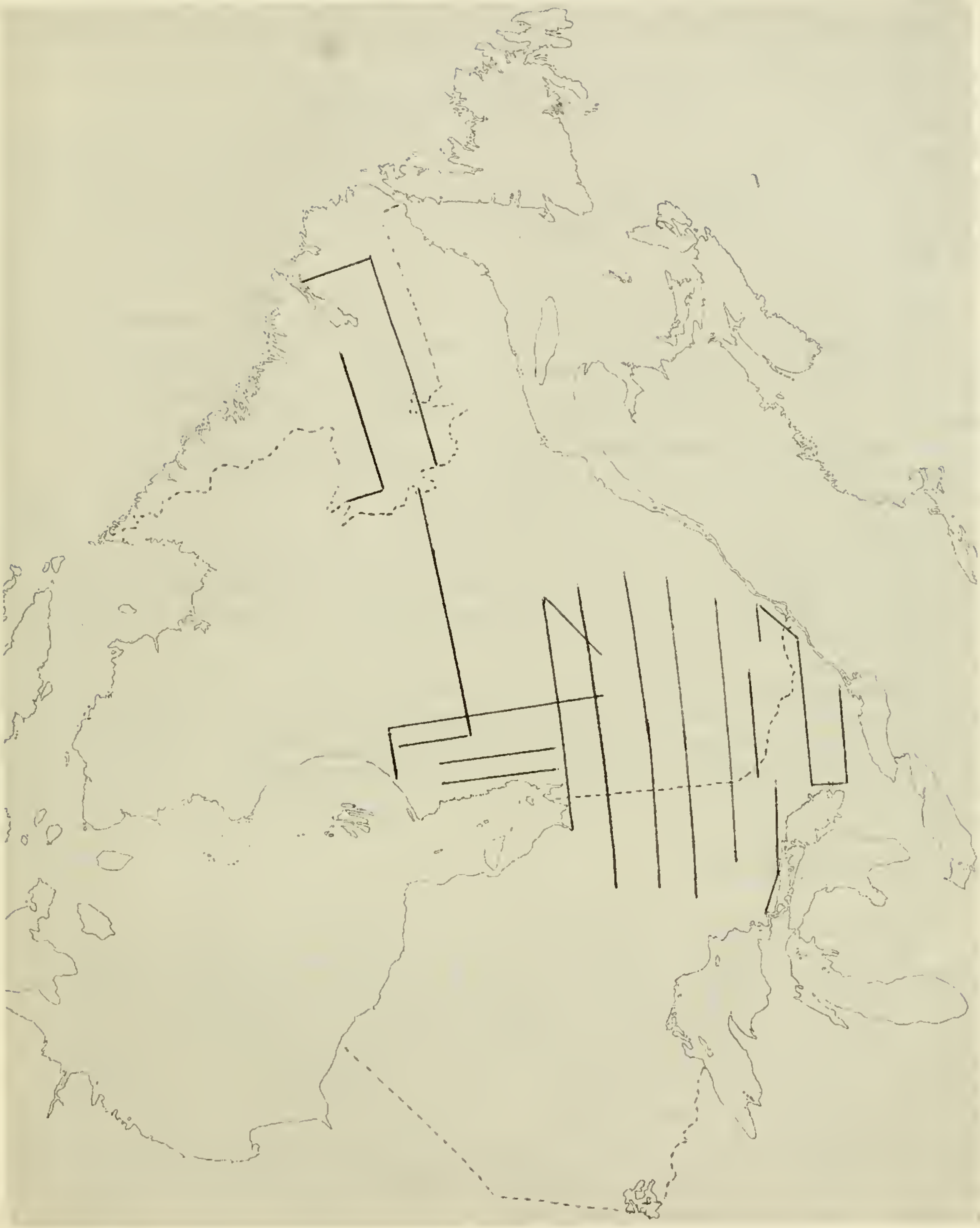

Figure 2.--Black duck survey sampling plan.

Canada Goose Survey Methods

Geese seen per square mile in 1956 and for the years 1962 through 1965 were plotted within one-degree-block units of latitude and longitude to determine differences in goose density within the survey area. The survey area was then divided into strata showing density differences. Broods were given an average value of six (two adults, four young) and combined with other geese seen. Data from earlier years were examined but survey coverage was considered too restricted to contribute balanced information for stratification. The turnover in aerial crew personnel during the early years and the possibility of changes in the distribution of goose populations with the passage of time were also considered in this decision.

Annual indexes were based upon density strata; in each stratum, the average density per square mile was computed and multiplied by the number of square miles in the stratum. The figures for all strata were then totaled. This approach seemed better than either comparing numbers of geese seen over the total area, which was biased by non-uniform sampling of density areas, or comparing those degree blocks of latitude and longitude covered in consecutive years, which led to a sharp reduction in the originally small sample.

Survey results in 1962 were too low and variable, possibly due to crew inexperience. These data were used for stratification but were exempted from estimates of optimum sample allocation and comparison of population levels.

Statistical procedures described by Snedecor (1956) were used to examine sampling error in the stratified sample and to make estimates of optimum sample allocation and confidence limits. Since the samples were not taken randomly and since the goose observations do not approximate a normal distribution, the results are considered to be rough estimates.

Black Duck Survey Methods

The heavily forested habitat preferred by breeding black ducks limits the proportion of ducks that can be observed on an aerial survey. In addition, the proportion seen is affected by the phenology of the breeding season as determined by climatic conditions. An extreme example of this is the "pile-up" of ducks that the survey may encounter during a year when late ice break-up delays northward migration. While "pile-ups" show obvious evidence of a bias in numbers of ducks observed, less discernible variables are also probable because of local and annual climatic variations during the time of aerial survey. This problem and a method designed to overcome it have been described (Chamberlain and Kaczynksi, 1965). The method, referred to as the "group-characteristic procedure," compares similar group sizes such as singles, pairs, and

groups of three, which represent birds apparently at similar stages in nesting phenology. In the present report, as a result of having more data available for examination, we use some modifications of the original method.

CANADA GOOSE SURVEY - FINDINGS

Canada Goose Density Strata

Canada goose populations in eastern Canada differed markedly in density over their range. The six strata outlined in figure 3 are based on the combined results of surveys in 1956 and 1962 through 1965. No modification in strata boundaries was made after 1965. Annual indexes per stratum for 1956 and years after 1961 are shown, together with period averages for the strata, in table 1. The sharp irregularities in stratum boundaries resulted from delineating strata according to degree blocks to which the observations were assigned.

Exceptionally large numbers of geese, both flocked adults and broods, were found each year in stratum A on the Hudson Bay side of the Ungava Peninsula (fig. 3). Geese seen there were concentrated near the coast and their number decreased rapidly toward the interior, so that a low density area (stratum E) could be defined to the east and south. Another high density area surrounded the western and southern shores of Ungava Bay (stratum B). The density in stratum B was only about half as great as that in stratum A, but was much higher than in all other strata. Here again, observations of geese decreased quite rapidly away from the coast, but to the south they were sufficient to designate areas of medium density (stratum C). Stratum F included the southern extremity of the breeding range, where observations of geese were markedly fewer than in areas to the north, including low density stratum E. Because few geese were observed in the eastern margin of the surveyed area, it was considered part of stratum F. Surveys in 1964-66 west of James Bay (stratum D) showed a density appreciably higher than other areas of similar latitude but lower than stratum C.

A reservation concerning the use of density strata is that observations of geese may vary with survey conditions. For example, the lower counts obtained in the northeast extension of stratum F must result in part from the rugged terrain which required the survey to be flown at a higher altitude. Under these conditions, geese were less conspicuous because of the altitude and the increased attention required for flying. Vegetative differences between forest and tundra probably also effect the numbers of geese observed. Although density differences appear great enough to reflect actual differences in the distribution of geese, the variables mentioned undoubtedly contribute to these differences.

Table 1.--Canada goose densities and population indexes taken by aerial survey in eastern Canada, 1956 and 1962-66

		Strata						
		A	B	C	E	F	Total (A-F)	D
Area in square miles		31,517	16,661	51,874	133,992	216,501	450,545	42,383
Geese per sample square mile	1956	9.68	5.75	0.87	0.30	0.08		--
	1962	6.29	1.72	0.73	0.20	0.06		--
	1963	9.92	4.49	1.80	1.00	0.15		--
	1964	11.14	5.28	1.66	0.46	0.13		0.80
	1965	11.66	7.59	2.09	0.51	0.17		1.17
	1966	7.01	6.29	1.54	1.00	0.50		0.54
6-year average		9.28	5.19	1.45	0.58	0.18		0.84
Goose index (density x area)	1956	305,085	95,801	45,130	40,198	17,320	503,534	--
	1962	198,242	28,657	37,868	26,798	12,990	304,555	--
	1963	312,649	74,808	93,373	133,992	32,475	647,297	--
	1964	351,099	87,970	86,111	61,636	28,145	614,961	33,906
	1965	367,488	126,457	108,417	68,336	36,805	707,503	49,588
	1966	220,934	104,798	79,885	133,992	108,250	647,859	22,887
Percent change 1965 to 1966		-40	-17	-26	+96	+194	-8	-54
6-year average		292,583	86,415	75,131	77,492	39,331	570,952	35,460
6-year average percent of total index		51.2	15.1	13.1	13.6	6.9	99.9	
Percent of total area		7.0	3.7	11.5	29.7	48.1	100.0	

Stratum	Title	Density[1]
A	Western high	9.28
B	Eastern high	5.19
C	Eastern medium	1.45
D	Western medium	0.84
E	Northern low	0.58
F	Southern low	0.18

[1] Average observed density 1956, 1962-66 for all strata except D (1964-66).

Figure 3.--Canada goose density strata in eastern Canada (geese per square mile).

Estimates of Confidence Limits and Optimum Sample Allocation for the Stratified Canada Goose Survey

The 95 percent confidence limits of the stratified Canada goose sample have varied from ± 21 percent of the mean in 1966 to ± 44 percent of the mean in 1962 (table 2). Calculation of the optimum sample allocation, as indicated by the results of the last 4 years of survey (table 3), shows that the sampling intensity should be increased in stratum A. These data indicate that from 44 to 51 percent of the total sample should be allotted to stratum A. The 1966 data indicate an allotment of only 23 percent for that year because the variability of the data from stratum A was markedly lower while that for stratum E was markedly higher.

Table 4 shows estimates of the improvement in confidence limits which might have resulted if optimum allocation of samples had been made from 1963 to 1966. These estimates, based upon the average of the estimated allotment in table 3, reveal that, with optimum allocation, confidence limits below ± 20 percent of the mean would have occurred. Because of the apparently atypical results in the 1966 sample, the sample taken in that year showed better confidence limits (± 21 percent) than would have resulted from optimum allocation (± 23 percent).

Canada Goose Summer Indexes Compared With Winter Survey and Kill Statistics

Population estimates compiled by surveys in eastern Canada may be compared in a general manner with the winter survey and kill figures. Sampling error in the summer index is high relative to the apparent annual changes. The reliability of winter survey counts is unknown. Also, there is little basis for a delineation of comparable reference areas, summer to winter, north to south. It appears that breeding geese from any particular northern area may distribute themselves widely in their choice of wintering areas. For example, in the summer of 1965, an extensive banding operation, in the vicinity of Povungnituk, Quebec, detected that most of the banded flightless adults taken had been banded in the Mississippi Flyway (personal communication, J. D. Heyland). If this trapped sample is representative of the high density area (stratum A) on the western side of the Ungava Peninsula, it indicates that the geese in the area, which provide about half of the total summer index, are associated with both the Mississippi and Atlantic Flyways.

Table 5 compares summer index values from the Canada goose survey with numbers of geese accounted for in winter surveys and kill estimates. The summer index is compared with the following winter survey and fall and winter kill estimate.

Figures 4 and 5 illustrate the relation of the values in table 5. The population levels represented by the summer index east of James and Hudson Bays were similar to those indicated in the Atlantic Flyway

Table 2.--Computation of standard error and confidence limits for stratified Canada goose samples (see Snedecor, 1956, p. 506)

Year	Stratum	Stratum weight (W)	Segments (n)	Mean ($\bar{y}$)	Total weighted mean ($\sum W\bar{y}$)	Variance (s^2)	Standard error $\sqrt{\Sigma W^2 s^2/n}$	At 95 percent confidence level: Confidence limits $2\sqrt{\Sigma W^2 s^2/n}$	At 95 percent confidence level: Confidence limits (percent of mean)
1956	A	.07	36	43.56		3,760.20			
	B	.04	29	25.86		2,164.85			
	C	.11	61	3.90		65.88			
	E	.30	112	1.21		10.08			
	F	.48	124	0.38		1.24			
		1.00	362		5.06		.8090	±1.62	±32
1962	A	.07	25	28.32		2,090.00			
	B	.04	8	7.75		57.44			
	C	.11	44	3.27		41.36			
	E	.30	90	0.89		7.20			
	F	.48	87	0.25		1.74			
		1.00	254		3.04		.6669	±1.33	±44
1963	A	.07	23	44.65		4,031.90			
	B	.04	5	20.20		119.05			
	C	.11	47	8.11		112.80			
	E	.30	92	4.50		95.68			
	F	.48	133	0.69		5.32			
		1.00	300		6.51		1.0140	±2.03	±32
1964	A	.07	53	50.11		5,321.20			
	B	.04	21	23.76		1,165.50			
	C	.11	49	7.37		102.90			
	E	.30	134	2.09		25.46			
	F	.48	148	0.58		2.96			
		1.00	403		6.17		.7924	±1.58	±26

Table 2.--Computation of standard error and confidence limits for stratified Canada goose samples (see Snedecor, 1956, p. 506)--continued

Year	Stratum	Stratum weight (W)	Segments (n)	Mean ($\bar{y}$)	Total weighted mean ($\sum W\bar{y}$)	Variance (s^2)	Standard error $\sqrt{\sum W^2 s^2/n}$	At 95 percent confidence level: Confidence limits $2\sqrt{\sum W^2 s^2/n}$	At 95 percent confidence level: Confidence limits (percent of mean)
1965	A	.07	65	52.49		4,718.35			
	B	.04	30	34.17		2,605.80			
	C	.11	27	9.41		93.42			
	E	.30	54	2.09		21.60			
	F	.48	119	0.75		7.14			
		1.00	295		7.06		.7658	± 1.53	± 22
1966	A	.07	75	30.97		1,545.75			
	B	.04	35	28.29		1,804.25			
	C	.11	41	7.07		115.62			
	E	.30	85	4.13		56.95			
	F	.48	109	2.26		64.31			
		1.00	345		6.36		.6432	± 1.29	± 21

Table 3.--Calculation of optimum sample allocation for stratified Canada goose sample (Snedecor, 1956, p. 508)

Year	Stratum	Stratum weight (W)	Standard deviation (s)	Ws	Percent allotment Ws/Σ Ws	Average percent allotment 1963-66
1963	A	.07	63.50	4.45	44	
	B	.04	10.91	0.44	4	
	C	.11	10.62	1.17	12	
	E	.30	9.78	2.93	29	
	F	.48	2.30	1.10	11	
				10.09	100	
1964	A	.07	72.94	5.11	51	
	B	.04	34.15	1.37	14	
	C	.11	10.14	1.12	11	
	E	.30	5.05	1.52	15	
	F	.48	1.72	0.83	8	
				9.95	99	
1965	A	.07	68.67	4.81	45	
	B	.04	50.98	2.03	19	
	C	.11	9.67	1.06	10	
	E	.30	4.63	1.39	13	
	F	.48	2.73	1.31	12	
				10.60	99	
1966	A	.07	39.32	2.75	23	41
	B	.04	42.47	1.70	15	13
	C	.11	10.75	1.18	10	11
	E	.30	7.55	2.27	19	19
	F	.48	8.02	3.84	33	16
				11.74	100	100

Table 4.--Estimation of improvement in confidence limits from use of optimum sample allocation for stratified Canada goose sample, based on years 1963-66 (table 3)

Year	Stratum	Recommended sample (n)	Stratum weight² (W^2)	Variance (s^2)	Standard error $\sqrt{\Sigma W^2 s^2/n}$	95 percent confidence limits (percent of mean) Before allocation	After allocation
1963	A	123	.0049	4,031.90			
	B	39	.0016	119.05			
	C	33	.0121	112.80			
	E	57	.0900	95.68			
	F	48	.2304	5.32			
		300			.6198	32	19
1964	A	165	.0049	5,321.20			
	B	52	.0016	1,165.50			
	C	44	.0121	102.90			
	E	77	.0900	25.46			
	F	64	.2304	2.96			
		402			.5132	26	17
1965	A	121	.0049	4,718.35			
	B	38	.0016	2,605.80			
	C	32	.0121	93.42			
	E	56	.0900	21.60			
	F	47	.2304	7.14			
		294			.6377	22	19
1966	A	141	.0049	1,545.75			
	B	45	.0016	1,804.25			
	C	38	.0121	115.62			
	E	66	.0900	56.95			
	F	55	.2304	64.31			
		345			.7082	21	23

Table 5.--Winter survey and kill data compared with summer indexes of Canada geese

Source of data	1962-63	1963-64[1]	1964-65[1]	1965-66[1]	1966-67[1]
Atlantic Flyway					
Winter survey	477,305	528,200	482,500	600,200	604,000
Kill estimate	99,410	144,183	144,927	94,332	162,864
Winter survey and kill	576,715	672,383	627,427	694,532	766,864
Mississippi Flyway					
Winter survey	434,952	422,513	443,810	381,380	482,000
Kill estimate	97,791	127,454	173,145	163,330	178,893
Winter survey and kill	532,743	549,967	616,955	544,710	660,893
Summer index east of James and Hudson Bays	--	647,297	614,961	707,503	645,319
Summer index from strata B, C, E and F	--	334,648	263,862	340,015	428,482

[1] Summer index of 1963, winter data of 1963-64 etc.

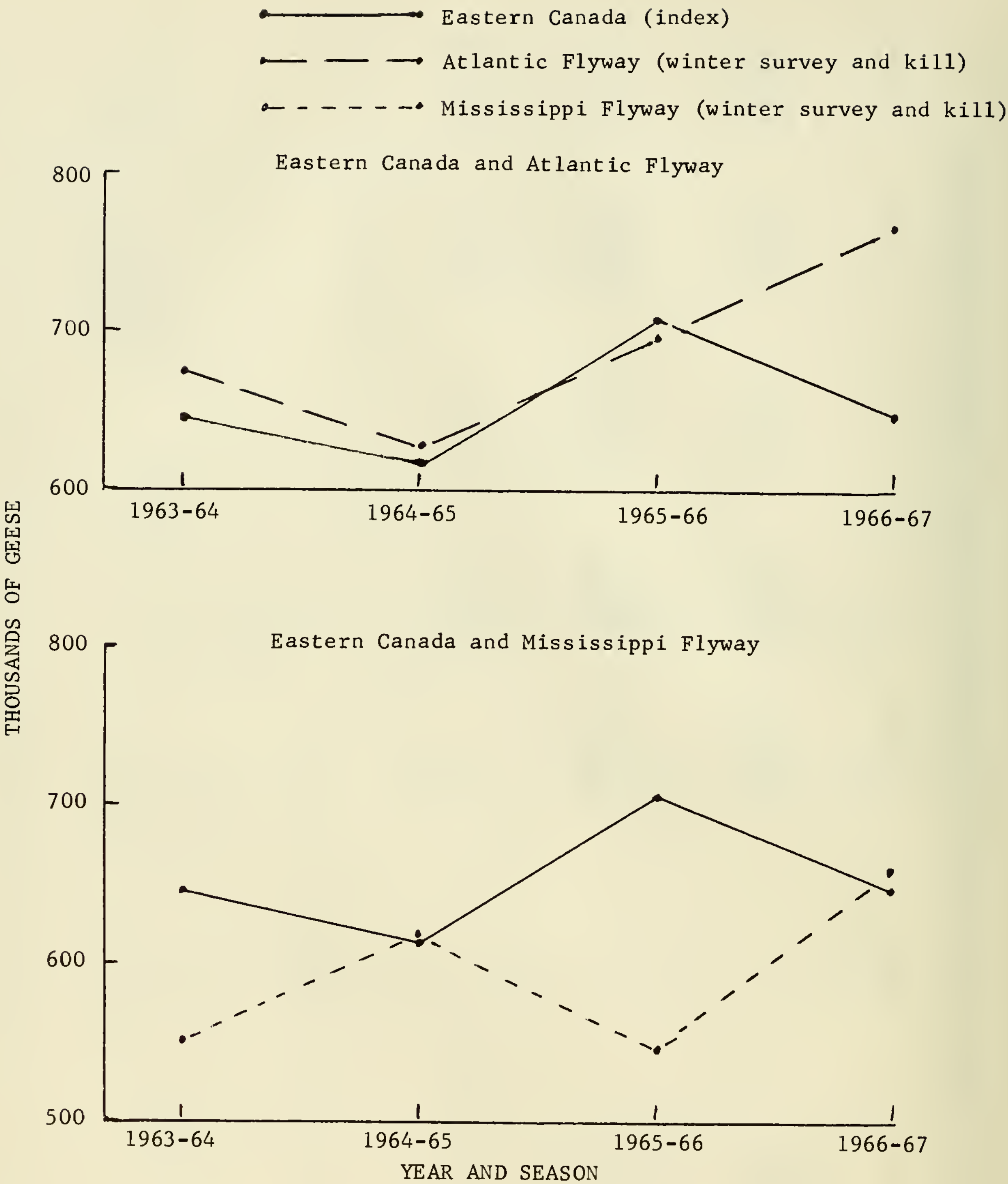

Figure 4.--Summer Canada goose index from Canada east of James and Hudson Bays compared with following winter survey and kill data in the United States.

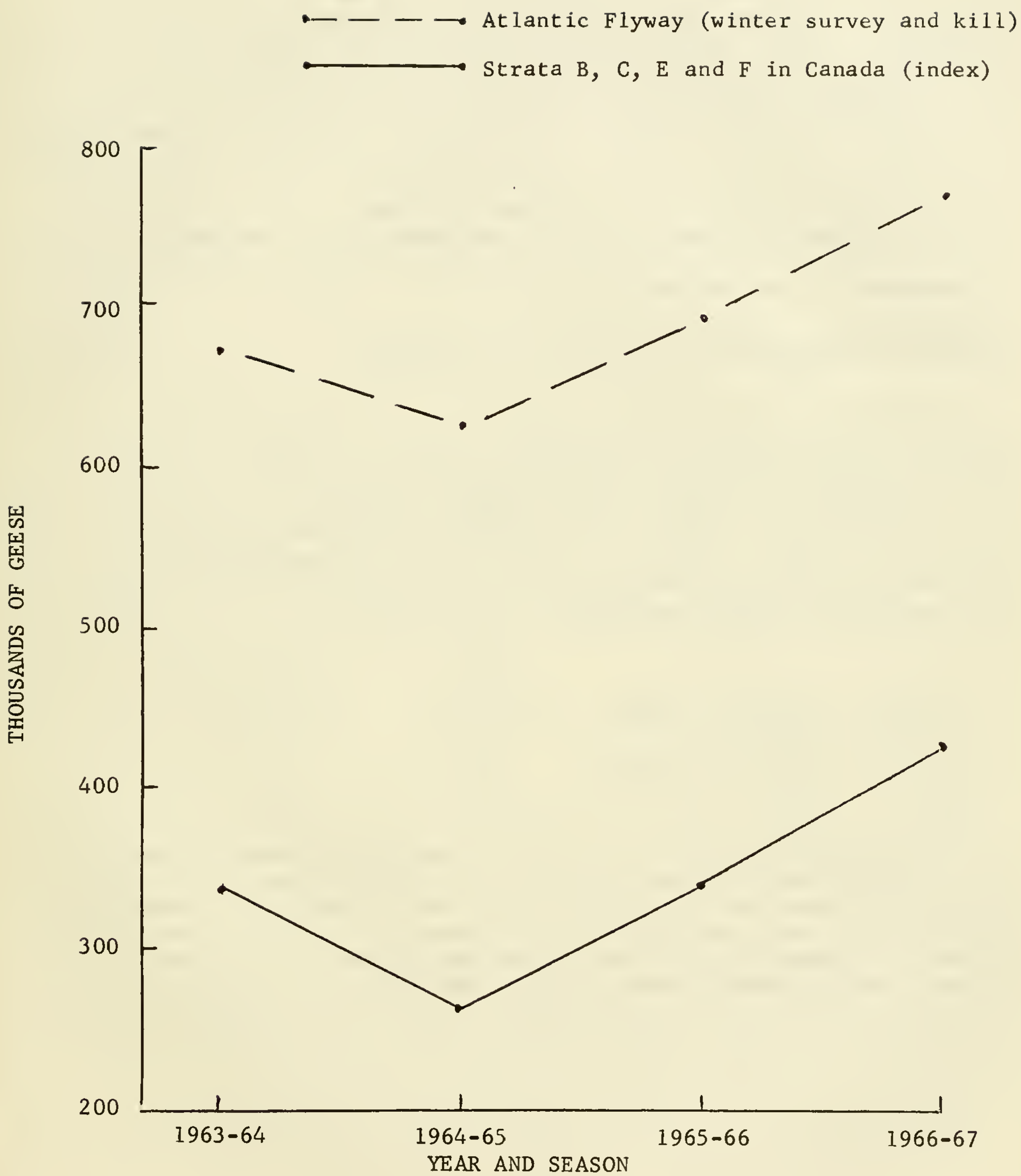

Figure 5.--Summer Canada goose index from strata B, C, E and F compared with following winter survey and kill data in the Atlantic Flyway.

winter survey and kill from 1963-64 to 1965-66. However, from 1965-66 to 1966-67 the two surveys show a diverging trend (fig. 4). Comparison of summer index values east of James and Hudson Bays with Mississippi Flyway winter survey and kill figures shows opposition in trend every year since 1963-64 (fig. 4). Comparison of summer index values from strata B, C, E, and F (high density stratum A omitted) with Atlantic Flyway winter survey and kill estimates shows agreement in trend every year since 1963-64 (fig. 5). However, the index from this portion of the breeding ground approximates only one-half of the Atlantic Flyway winter survey and kill. While it is likely that nearly all geese present are observable on the transects in the tundra, a lesser proportion are probably observed when forested areas are surveyed. Also, it is likely that some geese in the western portions of strata E and F are associated with the Mississippi Flyway. Both of the above effects may account for the low index value from strata B, C, E, and F compared with Atlantic Flyway winter population estimates.

Canada Goose Summer Survey and Hunting Regulations

Annual hunting regulations are set on July 15 in Canada and August 1 in the United States. The summer survey for Canada geese is not usually completed until mid-August. Hence, the latest data on the Canada goose breeding population and production is not available for consideration at regulations hearings. Completion of the summer survey earlier than August 1 is not feasible if maximum production figures are to be included in the index. Markedly lower brood counts on transects 19 through 22 (fig. 1) in eastern Ungava Peninsula were associated with early survey dates, as shown below:

Year	Dates of survey	Total broods	"Downy young" broods
1965	July 20, 21	7	2
1964	July 27 - August 2	28	1
1966	August 9, 10	50	1

The infrequent recording of the smallest "downy young" broods, even at the earlier dates, suggests that surveys conducted too early will lead to low counts not only because fewer broods have been produced, but also because young broods are more difficult to observe than are older broods. Unless setting the hunting regulations for Canada geese is delayed, data adequately representing production in the highest density area in Canada cannot be made available for current regulations hearings.

Observed Black Duck Densities

Black duck densities did not differ enough between areas, and differences between years were not consistent enough to justify stratification of the sample area (Chamberlain and Kaczynski, 1965). Figure 6 shows the density per square mile within the arbitrarily selected blocks in the survey area. These figures are based upon the average of the years 1955, 1956 and 1963-66. Total number of square miles sampled in all years is also shown.

The two southernmost blocks yielded below-average densities, but this may be related to a phenological difference rather than a density difference since, at the time of survey, nesting tends to be more advanced in southern than in northern areas. When nesting is advanced, hens flush less readily and drakes may have left the area. Lower than average densities in the tier of blocks next to the St. Lawrence River were probably related to difficult survey conditions caused by the mountainous terrain in much of that area.

Data for the Labrador area are primarily from surveys in 1955 and 1956. For most years from 1963 to 1966, the ice-line prevented making the survey during the required period of time. The relatively high density of black ducks in the northernmost and easternmost blocks indicates that the survey does not reach the northern limit of the black duck breeding population. However, a greater proportion of the ducks present may be counted in the more barren northern blocks than in the heavily forested southern blocks and the importance of the more northern areas may be exaggerated.

Estimation of Black Duck Breeding Population Trends in Eastern Canada

The group-characteristic procedure (Chamberlain and Kaczynski, 1965) was used in estimating trends of black duck breeding populations in eastern Canada to reduce the bias imposed by different stages of breeding as the survey progressed northward. There is a correlation between the progress of the breeding season and the manner in which ducks are grouped. For example, early in the season, paired birds are most common. Later in the season, as the hen becomes attached to the nest, more single birds (males) are seen. Still later, the males congregate into small flocks and fewer pairs or singles are seen. The group-characteristic procedure divides the survey area into southern, central, and northern zones (fig. 7), and uses only the degree blocks sampled every year. For each zone and year we computed the total number of black ducks seen per square mile and the number of (1) singles, (2) pairs, (3) groups of three, and (4) groups of from four to 10. Flocks larger than 10 were omitted because their occurrence was sporadic. The sizes and occurrence, by year and zone of the flocks omitted, are as follows:

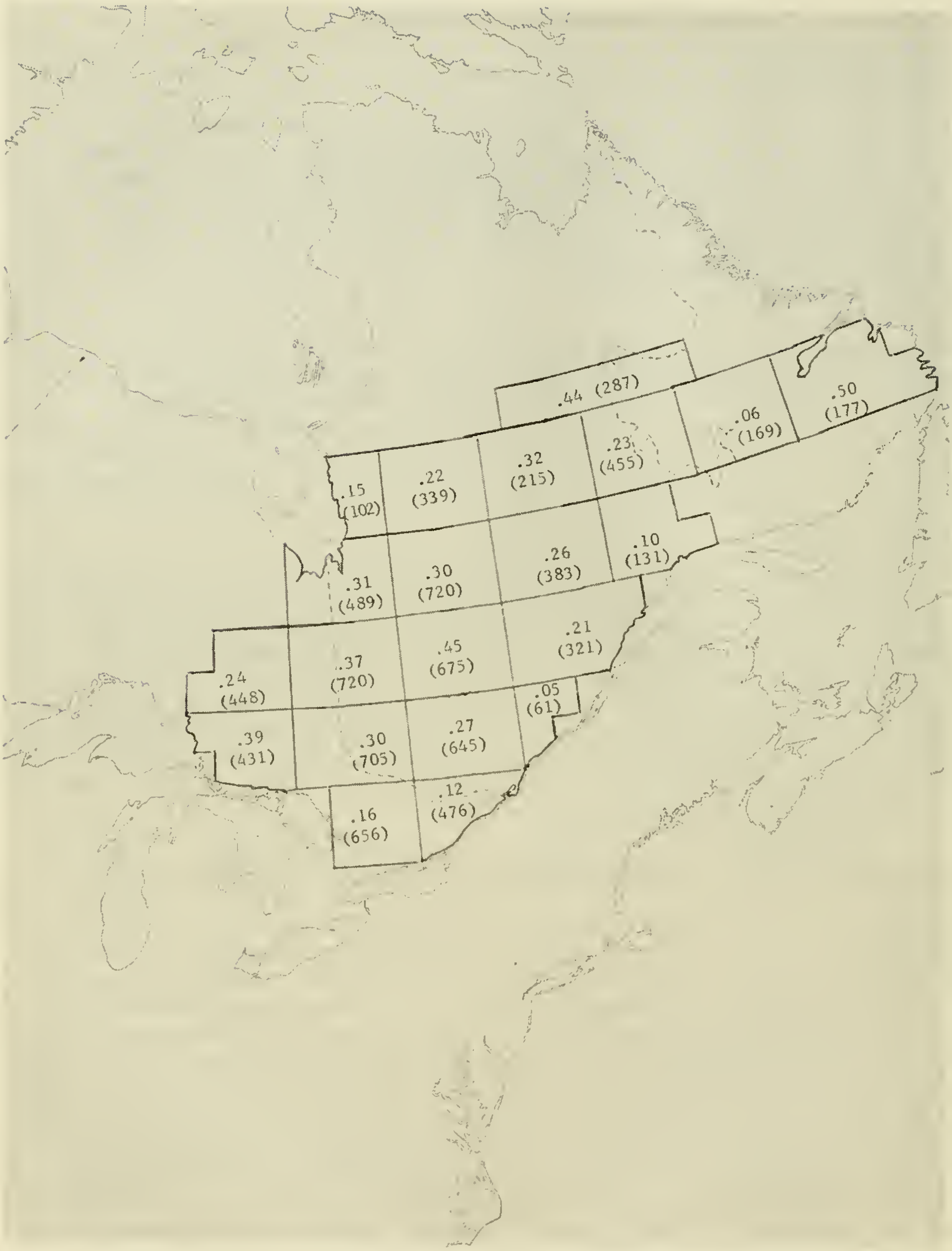

Figure 6.--Observed black duck densities per square mile based upon average of observations for 1955, 1956 and 1963-66. Numbers in parentheses indicate number of square miles sampled in all years combined.

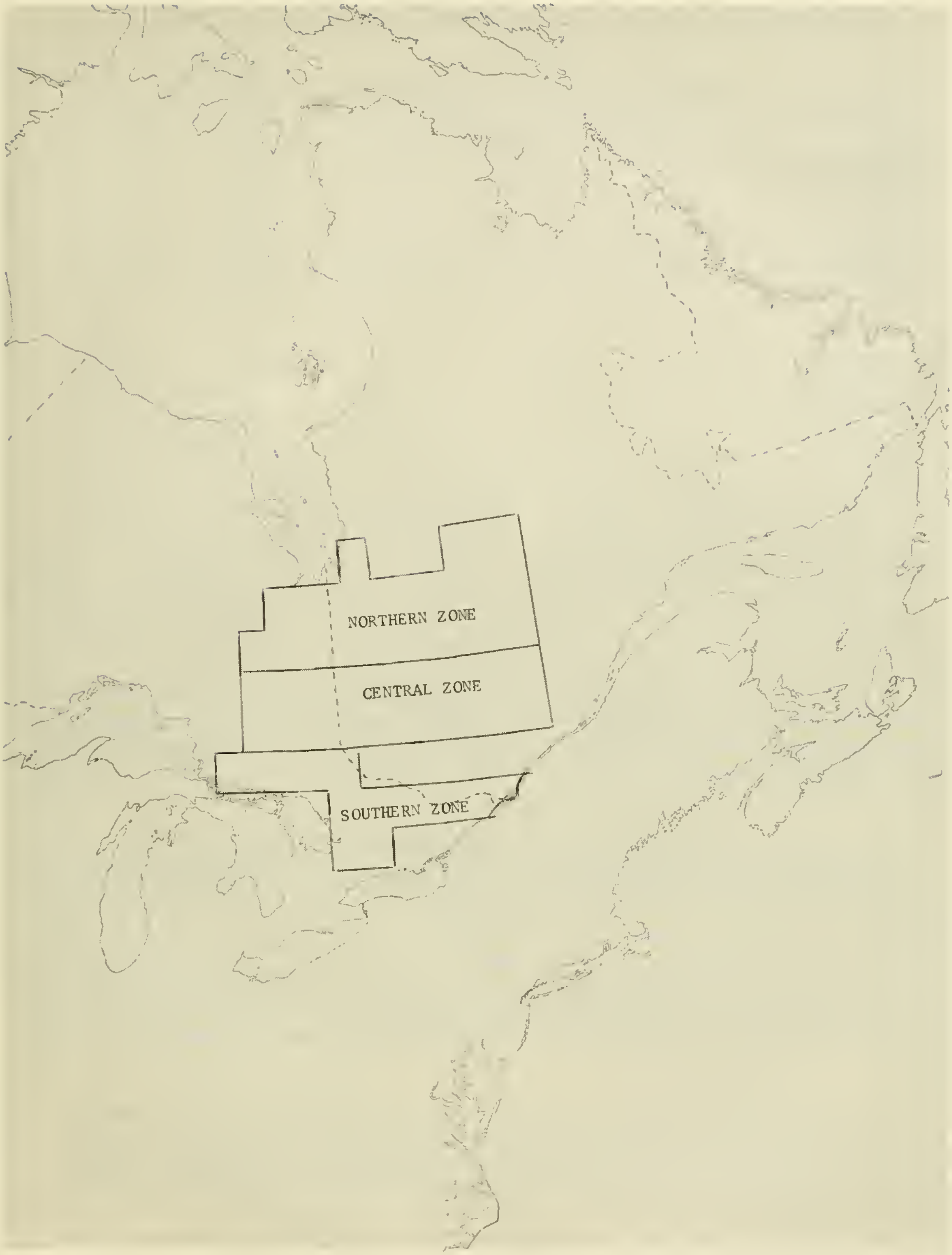

Figure 7.--Zonal division of degree blocks sampled for black ducks, 1955-56 and 1963-66.

Occurrence and sizes of black duck flocks larger than ten

Year	Zone			Total	
	Southern	Central	Northern	Ducks	Flocks
1955	0	11,12,13	0	36	3
1956	0	13	15	28	2
1963	0	35	0	35	1
1964	0	0	0	0	0
1965	20	25	0	45	2
1966	0	16	30	46	2
All years:					
Ducks	20	125	45	190	--
Flocks	1	7	2	--	10

Densities in each group class were ranked as high, medium, or low in relation to the mean density for all 6 years of survey (table 6). Values falling within the range of the mean, plus or minus 1 standard error, were arbitrarily considered medium, while values outside that range were considered high or low.

In table 7, agreement or disagreement in these rankings between any 2 years for each group of ducks is quantified by assigning a value of two when rankings agreed (high-high, low-low, medium-medium), a value of one for combinations of medium with either high or low, and no value for greatest difference in combinations (high-low). Thus highest comparability (2) in each of the four groups would provide a maximum agreement index of eight. Only comparisons that resulted in an index of five or higher are shown in table 7.

For those years considered most comparable (agreement index of five or greater, table 7) we plotted total densities (excluding flocks larger than 10) for each zone and year (fig. 8). Lines were drawn between the comparable points. For example, in the northern zone, 1955 data were comparable only to 1956 and 1964 data (table 7). Therefore, in figure 8, lines are drawn from 1955 to only 1956 and 1964. With the exception of the central zone from 1955 to 1963, every comparison, thus selected, of an earlier year with a later year showed a decrease in density.

An average density trend for the combination of zone-year comparison is shown by the doubled line in figure 8. The points on this line were determined from the average of all points and intersects in figure 8. In determining the average trend line, zone densities were weighted by area.

Table 6.--Densities of black ducks determined from breeding population surveys in eastern Canada

Zone	Year	Average density per square mile by groups: Singles	Pairs	Groups of three	Groups of 4 to 10	Square miles in sample	Number of ducks	Total (1-10) density per square mile
Southern	1955	.054(M)[1]	.136(H)	.041(H)	.000(L)	220.5	51	.231
	1956	.050(M)	.163(H)	.000(L)	.000(L)	220.5	47	.213
	1963	.044(L)	.074(L)	.000(L)	.030(H)	135.0	20	.148
	1964	.074(H)	.074(L)	.022(H)	.000(L)	135.0	23	.170
	1965	.058(M)	.090(M)	.019(M)	.013(M)	310.0	56	.180
	1966	.052(M)	.052(L)	.010(M)	.016(M)	310.0	40	.130
	$\bar{x} \pm$ 1 S.E.	.046-.064	.081-.115	.009-.021	.000-.021			
Central	1955	.062(M)	.123(L)	.041(H)	.147(H)	292.5	109	.373
	1956	.068(M)	.342(H)	.021(L)	.068(M)	292.5	146	.499
	1963	.072(M)	.196(M)	.034(H)	.117(H)	265.5	111	.419
	1964	.097(H)	.145(L)	.014(L)	.092(M)	207.0	72	.348
	1965	.087(M)	.192(M)	.022(L)	.031(L)	415.5	138	.332
	1966	.065(M)	.091(L)	.034(H)	.054(L)	353.0	86	.244
	$\bar{x} \pm$ 1 S.E.	.062-.088	.146-.218	.024-.032	.067-.101			
Northern	1955	.034(L)	.114(H)	.034(H)	.066(M)	351.0	87	.248
	1956	.020(L)	.080(M)	.000(L)	.085(M)	351.0	65	.185
	1963	.068(H)	.154(H)	.028(M)	.114(H)	324.0	118	.364
	1964	.049(M)	.093(M)	.046(H)	.046(L)	324.0	76	.234
	1965	.059(H)	.071(L)	.029(M)	.106(H)	421.0	112	.266
	1966	.031(L)	.034(L)	.007(L)	.000(L)	417.0	30	.072
	$\bar{x} \pm$ 1 S.E.	.037-.051	.074-.108	.014-.031	.053-.087			
Total area	1955	.049	.123	.038	.076	864.0	247	.286
	1956	.044	.190	.007	.058	864.0	258	.299
	1963	.065	.155	.025	.099	724.5	249	.344
	1964	.070	.106	.032	.052	660.0	171	.260
	1965	.069	.120	.024	.054	1,146.5	306	.267
	1966	.048	.057	.017	.022	1,080.0	156	.144

[1] Letters indicate density classification as high (H), medium (M), or low (L).

Table 7.--Comparability indexes for groupings of black ducks and changes in density per square mile among years 1955, 1956 and 1963-66 (data resulting in total comparability index lower than 5 not shown)

Zone	Years compared	Comparability indexes for groups: Singles	Pairs	Groups of three	Groups of 4-10	Total (1-10) comparability index[1]	Comparative density (1-10) per square mile
Southern	1955-56	2	2	0	2	6	.231-.213
	1955-64	1	0	2	2	5	.231-.170
	1955-65	2	1	1	1	5	.231-.180
	1956-65	2	1	1	1	5	.213-.180
	1963-66	1	2	1	1	5	.148-.130
	1964-66	1	2	1	1	5	.170-.130
	1965-66	2	1	2	2	7	.180-.130
Central	1955-63	2	1	2	2	7	.373-.419
	1955-64	1	2	0	2	5	.373-.348
	1955-66	2	2	2	1	7	.373-.244
	1956-65	2	1	2	1	6	.499-.332
	1963-66	2	1	2	0	5	.419-.244
	1964-65	1	1	2	1	5	.348-.332
	1965-66	2	1	0	2	5	.332-.244
Northern	1955-56	2	1	0	2	5	.248-.185
	1955-64	1	1	2	1	5	.248-.234
	1956-66	2	1	2	1	6	.185-.072
	1963-65	2	0	2	2	6	.364-.266

1/ Total index of 8 indicates highest degree of comparability with regard to densities of various groups.

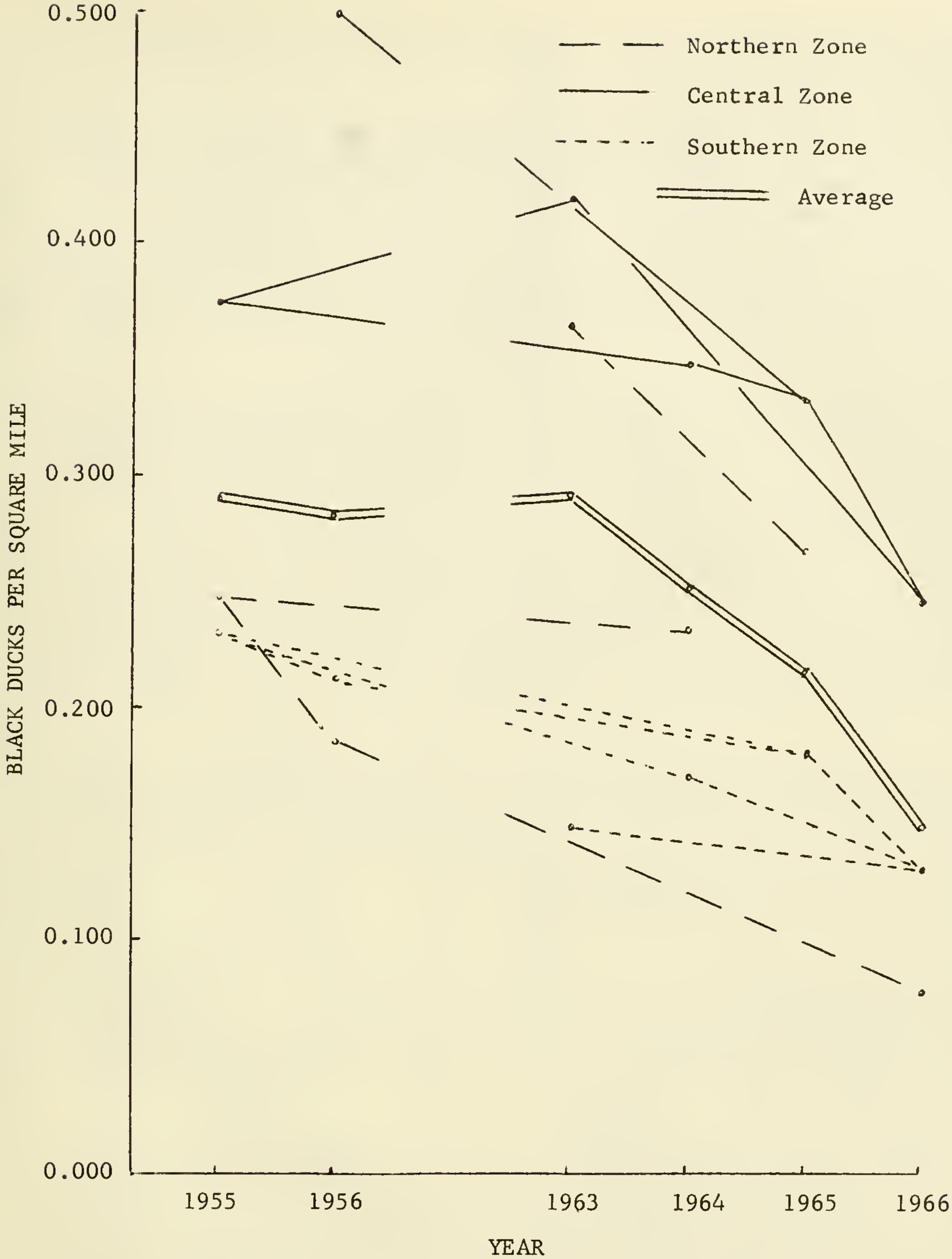

Figure 8.--Black duck density per square mile by zones. Lines drawn between years when surveys were judged most comparable. Zone-weighted average based on all points and intersects.

Comparison of Black Duck Breeding Population Trends With Wintering Population Survey Trends

Atlantic Flyway winter survey population data were grouped by five areas for comparison with the breeding pair population trends indicated by the group-characteristic procedure. These were (1) States north of Maryland and Delaware, (2) States south of Maryland and Delaware, (3) Maryland and Delaware plus States to the north, (4) Maryland and Delaware plus States to the south and (5) Atlantic Flyway. Wintering population survey figures (taken from annual Waterfowl Status Reports) for the above areas are shown in table 8, section A. Breeding pair populations are compared with the winter survey of the preceding winter.

All comparable (coverage) data from the breeding ground surveys are compared with Atlantic Flyway data only, although ducks surveyed in the more western part of the surveyed area are probably associated with both the Atlantic and Mississippi Flyways. For those years in which there was poor alignment in trend between the breeding ground survey and Atlantic Flyway winter population estimates (for example, see years 1963-1964, fig. 9), examination of Mississippi Flyway winter data did not show evidence of a compensatory effect. Also, the trial inclusions of several segments of Mississippi Flyway winter data with the Atlantic Flyway winter data did not provide a more credible trend relation with the breeding ground survey than that shown by the Atlantic Flyway winter data alone.

In comparing wintering ground trends with breeding population trends, the selected populations on the wintering ground were expressed in terms of their density relative to the breeding ground survey area and then reduced to the level of breeding ground survey densities (table 8). The reduction was based upon the average difference between the two surveys over all years compared.

The breeding ground survey density does not include that part of the breeding population seen as flocks larger than 10. The density is also underestimated because breeding populations are more difficult to observe than are wintering populations. Data from other species and habitats suggest that probably a small fraction of the black ducks present are seen in the breeding ground survey.

Comparison of trends from various parts of the population wintering in the Atlantic Flyway with the breeding population trend is shown in figure 9. The reduction factor (value with which the winter population density was multiplied so that it would correspond in average level with the breeding ground density) is also shown. The best correspondence in trend appears in the comparison between the breeding population and the population wintering south of Maryland and Delaware.

Table 8.--Sources and treatment of data for comparing breeding ground index trends and winter survey population trends for black ducks

Atlantic Flyway wintering area	1955	1956	1963	1964	1965	1966
			A - Winter survey populations			
North of Maryland-Delaware	199,557	152,156	146,930	177,000	183,300	141,200
South of Maryland-Delaware	133,803	96,026	122,170	103,000	68,200	62,100
Maryland-Delaware and north	448,650	328,817	203,030	262,600	261,600	242,700
Maryland-Delaware and south	382,896	272,687	178,270	188,600	146,500	163,600
Total Atlantic Flyway	582,453	424,843	325,200	365,600	329,800	304,800
			B - Breeding ground density per square mile			
	0.289	0.282	0.292	0.251	0.215	0.148
			C - Winter survey density relative to the breeding ground area reduced to level of group-characteristic density for trend comparison			
North of Maryland-Delaware	0.297	0.226	0.218	0.263	0.273	0.210
South of Maryland-Delaware	0.345	0.248	0.315	0.265	0.176	0.160
Maryland-Delaware and north	0.398	0.292	0.180	0.233	0.232	0.215
Maryland-Delaware and south	0.455	0.324	0.212	0.224	0.174	0.194
Total Atlantic Flyway	0.378	0.275	0.211	0.237	0.214	0.198

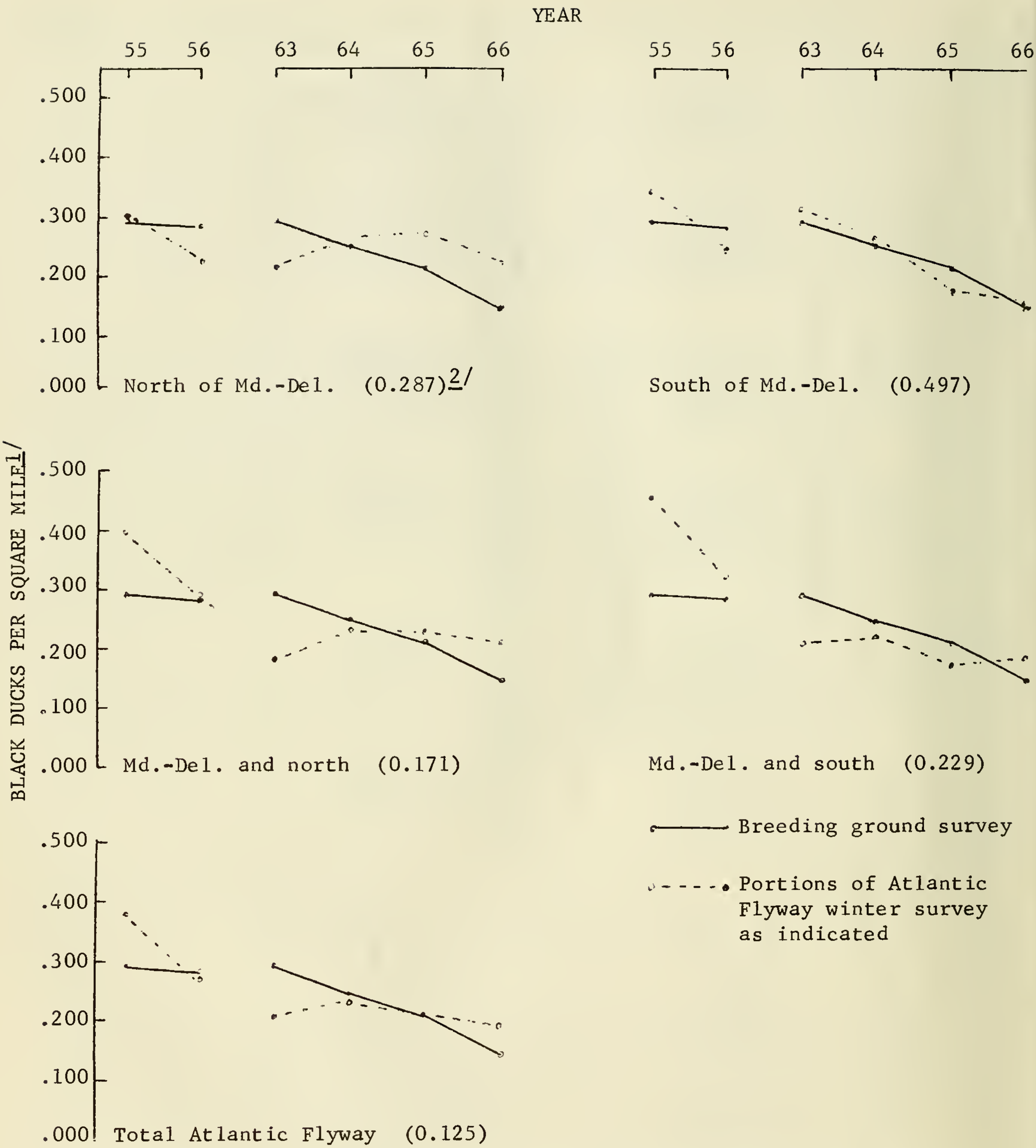

Figure 9.--Black duck population trend from the breeding ground survey compared with Atlantic Flyway winter survey trends.

1/ Density per square mile of breeding ground survey counts is based upon group characteristics procedures.

2/ Density per square mile of winter survey population relative to the breeding ground survey area is reduced to the level of breeding ground density to facilitate trend comparisons. The mean reduction factor is shown.

Approximation of the Proportion of Black Ducks Present That are Seen From the Air (visibility rate)

Indirect estimates of the black duck population using band recovery and kill data indicate that the black duck winter population is much larger than shown by winter surveys (data on file at the Migratory Bird Populations Station). Indirect estimates of population agree with summer and winter surveys in showing a population drop in recent years. While the average winter population in the 1950's was estimated to be 1.5 million black ducks, a population of 870,000 was estimated for 1964. If we accept this indirect estimate as the general population level of recent years and estimate the part of the total black duck breeding population that is within the survey area, it is possible to approximate the proportion of black ducks present that are seen from the air (visibility rate). It appears that 30 to 40 percent of the continental breeding population is resident in the summer survey area (data on file at the Migratory Bird Populations Station). We may approximate the proportion of breeding black ducks that are seen from the air (visibility rate) as follows:

Average breeding ground index (including flocks) 1963-66: 54,774.

Fraction of the breeding population within the summer survey area: 0.30 to 0.40.

Indirect estimate of wintering black ducks: 870,000.

Visibility rate = 54,774 ÷ .30 to .40 ÷ 870,000 = .16 to .21.

SUMMARY AND DISCUSSION

Canada Goose Breeding Population and Production Survey

Aerial surveys have increased our knowledge about the distribution of Canada geese on their breeding grounds, and this will aid in interpreting banding data in the future. Currently, there are several limitations to the usefulness of the summer survey as a management tool. These limitations include high sampling error, inadequate knowledge of seasonal distribution, and lateness of survey completion relative to the time of setting regulations.

Optimum sample allocation estimates show that, with the present resources and methods, sampling error can be reduced to a range of ± 17 to 20 percent of the mean (95 percent confidence level). This degree of precision would detect, as statistically significant, changes in the range of a 40 to 50 percent increase or of a 30 to 35 percent decrease.

Administrative use of summer goose data is hindered by inadequate knowledge of seasonal distribution, summer to winter. Comparisons of trends between summer survey indexes and winter survey figures suggest a relation between the summer survey area and the Atlantic Flyway. However, this relation must be viewed critically in the light of the degree of sampling error in the summer index (which alone may account for changes indicated since 1963) and the unknown reliability of the winter survey. Unless an extensive banding program can be conducted to show a consistent relation between summer and winter goose population by area, these relations will have to be surmised.

There is evidence that advancing the present schedule of the summer survey to make the data available in time for hearings on regulations would not be practical because it would result in greatly reducing the number of broods that could be observed. If the summer survey is not conducted at a time when broods can be observed, summer survey population estimates would be of little value and a winter survey would be preferable.

Black Duck Breeding Population Survey

Application of the group-characteristic procedure to data obtained from eastern Canada indicates a steadily declining breeding population since 1963 for that portion of the breeding range in Canada surveyed repeatedly.

A downward trend is indicated also by winter survey results south of Maryland and Delaware since 1963 and by winter survey results of the whole Atlantic Flyway in 1965 and 1966. We estimate that the survey area includes about 30 to 40 percent of the total breeding black ducks. It appears that the proportion of black ducks seen from the air is quite low, possibly 16 to 21 percent. The combination of limited area coverage and limited visibility provides a breeding population index that is about 6 percent of the total black duck population as computed by indirect estimation.

It is not possible to evaluate the relative effectiveness of the breeding ground survey and winter survey in indicating population changes because they can only be judged against each other. Knowledge of the distribution of black ducks on the breeding ground will be needed to interpret band recovery data properly. However, delineation of relative black duck densities from the survey data in eastern Canada will have to cope with a difficult problem of variable observation conditions coupled with a small sample of black ducks observed. The cost in time and money to develop and maintain a statistically reliable survey of the sparse population of breeding black ducks in eastern Canada appears prohibitive.

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